AISSCE 2018

PHYSICS PRACTICAL PROJECT

SRINATH SARAN BHAUMIK

BOARD ROLL NO.

DELHI PUBLIC SCHOOL, RUBY PARK, KOLKATA.

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CERTIFICATE

This is to certify that Srinath S. Bhaumik, a bonafide student of Delhi Public School Ruby Park, Class 12 has successfully completed his physics project on the making of sound reactive LED strip and a laser tripwire alarm system during the year 2017-18 as per CBSE guidelines for AISSCE Practical Examination 2018

External Examiner Internal Examiner

ACKNOWLEDGEMENT

I express my sincere gratitude towards my physics teacher who had given us the opportunity and space to explore new avenues for the physics project. Physics laboratory assistant, for standing with us throughout our endeavors; CBSE for providing us with a platform to illustrate our creativities; my friends for their unconditional support and cooperation. The book and websites need special mention as they led the foundation to my project, my parents, without whose guidance and perseverance, the project would never had been possible.

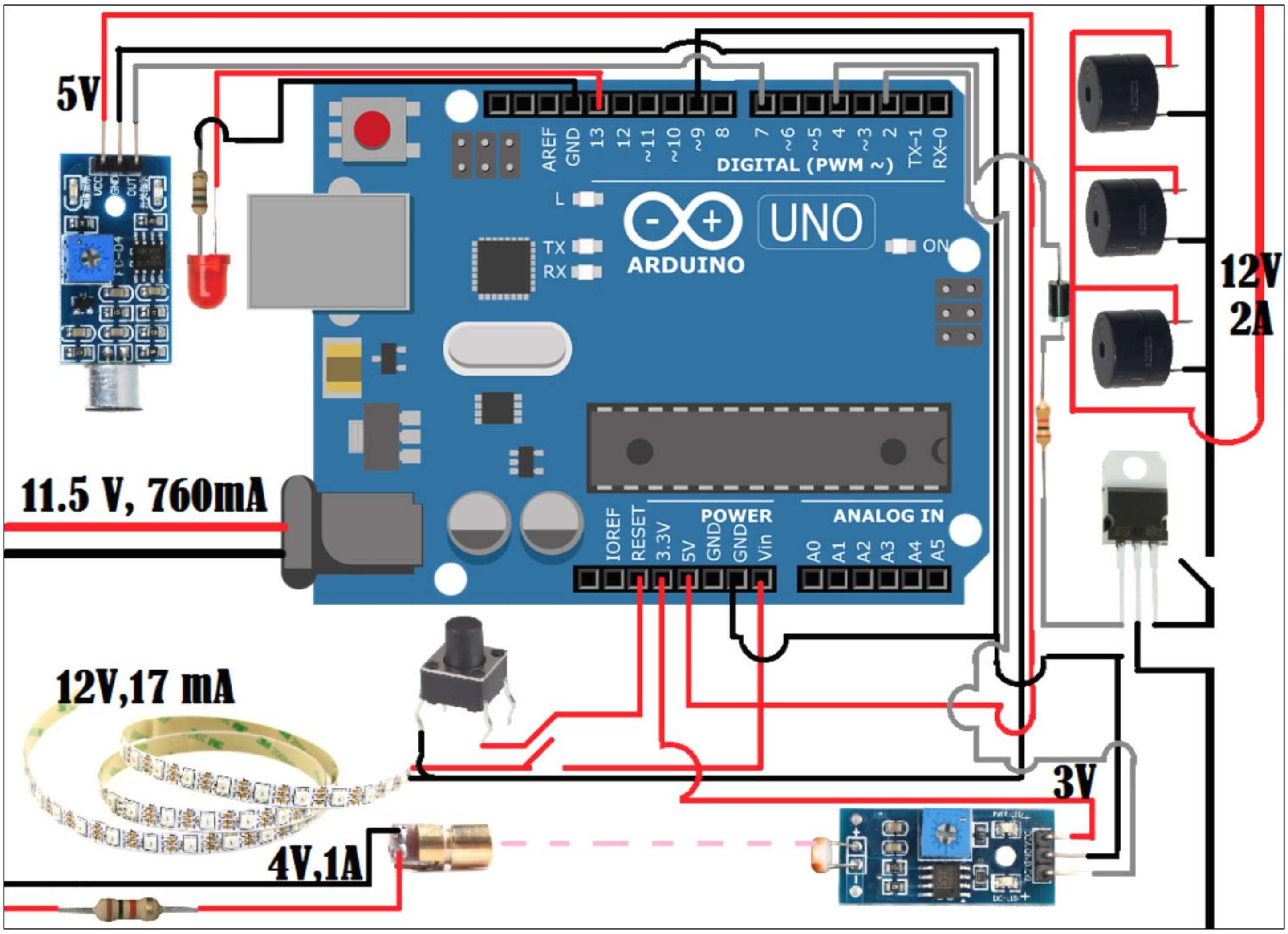
INRODUCTION

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

CONCEPT



Using the technological principles of the Arduino board (Uno) we will setup an analogue circuit wherein audio can be received from the surroundings using a sound sensor module equipped with a capacitive microphone and an onboard audio amplifier and potentiometer to adjust its sensitivity. The supply voltage will mediate in analogue values accordingly such that there is an active response in the luminosity of the LEDs

The laser tripwire alarm system works on the principle of an LDR as discussed later such that there is an active response to the buzzers lined parallel to the circuit as shown in the diagram, a separate laser emission unit is also setup.

THEORY

OHM'S LAW

Ohm's law is the most extensively used relation used in this project, it is a very important relation which administers the proper working of all planned DC circuits. The potential difference (voltage) across an ideal conductor is proportional to the current through it. The constant of proportionality is called the "resistance", R. Ohm's Law is given by: V = I R where V is the potential difference between two points which include a resistance R.

LIMITATIONS OF THE MICROCONTROLLER

The microcontroller can only supply a maximum of 20 mA through each port present as digital or analogue output,it can supply upto 40 mA through all the ports of the microcontroller. It can only work upto 12 V DC power supply, voltage regulator is inbuilt.

SOUND REACTIVE LED STRIP

The LED strip is powered by the VIN port of the microcontroller board such that it may receive unaltered operating voltage supplied to be of 11.5 V. The luminance of the LED depends on the voltage supplied to it within its working range, the negative terminal of the strip is connected to PWM ~9 (GND) such that there is analogue fluctuation in the operating voltage of the LED strip in accordance to the amplitude of the sound captured by the microphone in the sound detection module and calibrated sensitivity using the onboard potentiometer.

LASER TRIPWIRE ALARM SYSTEM

There is a light sensor module with integrated LDR, the sensitivity of which can again be set using an onboard potentiometer. The digital out of the module is connected to digital in pin #2. It is powered by the microcontroller of a steady flow of 3.3V. A circuit pin #4 (dO) is configured to complete the circuit whenever the resistance of LDR increases as the laser is pointed elsewhere or even blocked for a millisecond. Since the board can only supply a very small current, which is insufficient to make a loud sound using buzzers setup to alert when the connection is closed, the problem is eliminated using a separate DC power source of 12 V 2A. The positive terminal from the new voltage rail is connected parallel to 3 piezoelement buzzers and the ground terminal from the buzzers is connected to the emitter of a TIP122 transistor. The base of the transistor is connected to -12 V DC of the new voltage rail and the collector is connected to the circuit pin #4 dO in series of a diode restricting the backflow of current to the microcontroller and a 1 kilo ohm resistor to ensure only a very small amount of electricity just enough to trigger the transistor. The datasheet for the transistor has been provided.

WORKING OF AN NPN TRANSISTOR

The working of NPN transistor is quite complex. In the above circuit connections we observed that the supply voltage VB is applied to the base terminal through the load RB. The collector terminal connected to the voltage VCC through the load RL. Here both the loads RB and RL can limit the current flow through the corresponding terminals. Here the base terminal and collector terminals always contain positive voltages with respect to emitter terminal.

If the base voltage is equal to the emitter voltage then the transistor is in OFF state. If the base voltage increases over emitter voltage then the transistor becomes more switched until it is in fully ON state. If the sufficient positive voltage is applied to the base terminal i.e. fully-ON state, then electrons flow generated and the current (IC) flows from emitter to the collector. Here the base terminal acts as input and the collector-emitter region acts as output.

To allow current flow between emitter and collector properly, it is necessary that the collector voltage must be positive and also greater than the emitter voltage of transistor. Some amount of voltage drop presented between base and emitter, such as 0.7V. So the base voltage must be greater than the voltage drop 0.7V otherwise the transistor will not operate. The equation for base current of a bipolar NPN transistor is given by,

IB = (VB-VBE)/RB

Where,

IB = Base current
VB = Base bias voltage
VBE = Input Base-emitter voltage = 0.7V
RB = Base resistance

The output collector current in common emitter NPN transistor can be calculated by applying Kirchhoff's Voltage Law (KVL).

The equation for collector supply voltage is given as

VCC = ICRL + VCE ………… (1)

From the above equation the collector current for common emitter NPN transistor is given as

IC = (VCC-VCE)/RL

In a common emitter NPN transistor the relation between collector current and emitter current is given as

IC = β IB

In active region the NPN transistor acts as a good amplifier. In common emitter NPN transistor total current flow through the transistor is defined as the ratio of collector current to the base current IC/IB. This ratio is also called as "DC current gain" and it doesn't have any units. This ratio is generally represented with β and the maximum value of β is about 200. In common base NPN transistor the total current gain is expressed with the ratio of collector current to emitter current IC/IE. This ratio is represented with α and this value is generally equal to unity.

PRINCIPLE OF AN LDR

A Light Dependent Resistor (LDR) is also called a photoresistor or a cadmium sulfide (CdS) cell. It is also called a photoconductor. It is basically a photocell that works on the principle of photoconductivity. The passive component is basically a resistor whose resistance value decreases when the intensity of light decreases. This optoelectronic device is mostly used in light varying sensor circuit, and light and dark activated switching circuits. Some of its applications include camera light meters, street lights, clock radios, light beam alarms, reflective smoke alarms, and outdoor clocks.

WORKING OF A LASER DIODE

Laser is a narrow beam of Photons emitted by specially made laser diodes. Laser diode is similar to an ordinary LED, but it generates a beam of high intensity light. A laser is a device in which a number of atoms vibrate to produce a beam of radiation in which all the waves have single wavelength and are in Phase with each other. The most common laser diode generates semiconductor or injection laser. In these lasers, a population of Inversion Electrons is produced by applying a voltage across its p-n junction. Laser beam is then available from the semiconductor region. The p-n junction of laser diode has polished ends so that, the emitted photons reflect back and forth and creates more electron-hole pairs. The photons thus generated will be in phase with the previous photons. This will give a Pencil Beam and all the photons in the beam are Coherent and in phase.

A ruby laser most often consists of a ruby rod that must be pumped with very high energy, usually from a flashtube, to achieve a population inversion. The rod is often placed between two mirrors, forming an optical cavity, which oscillate the light produced by the ruby's fluorescence, causing stimulated emission. Ruby is one of the few solid state lasers that produce light in the visible range of the spectrum, lasing at 694.3 nanometers, in a deep red color, with a very narrow linewidth of 0.53 nm.

DATA

(ALL VALUES HAVE BEEN MEASURED USING A MULTIMETER)

POWER SUPPLY FOR MICROCONROLLER: 11.5V, 760mA

INDICATOR LED

LEDs have a forward voltage [V] and a forward current [mA]. Typically, the numbers of these two values can be found in the spec of the LED type. The LED used in this tutorial has a forward voltage of 2.2V and a forward current of 30mA. As the Arduino delivers 5V, 2.8V (5V-2.2V) have to be absorbed by a resistor. According to Ohm's Law R=V/I, a resistor with 93.3 ohms (2.8V/0.03A) is needed. Since one typically does not have an resistor with exactly 93.3 ohms, the next "higher" one is used. Therefore, a 150 ohms resistor is used. If the forward voltage/current is not known, the use of a 1k ohms resistor is safe in most cases.

TOTAL CURRENT THROUGHPUT VIA MICROCONTROLLER

Almost 21 mA (experimental), well below maximum rating of 40 mA

LASER DIODE POWER SUPPLY

The laser diode has a maximum rating of 5 volts, therefore for safety concerns we have used a 1 ohm resistor in series with the 5V 1A DC power supply to supply a steady voltage of 4V.

FLASHED CODE

//elapsedMillis library is imported from foreign sources, not provided by manufacturer//

```
#define LEDstrip 9
#include <elapsedMillis.h>

int LED = 13;
int LaserSensor = 2;
int SensorReading = LOW;
int alarmSpeaker = 4;
elapsedMillis timer0 ;
#define interval 0
boolean timer0Fired;

void setup() {
  pinMode(LED, OUTPUT);
  pinMode(7,INPUT);
  pinMode(LEDstrip, OUTPUT);
  pinMode(alarmSpeaker, OUTPUT);
  pinMode(LaserSensor, INPUT);
  timer0Fired = false;
   timer0 = 0;
}



void loop(){

  boolean soundstate = digitalRead(7);
  if (soundstate == 1) {
        analogWrite(LEDstrip, 255);
        delay(10);
  }
  else{

    analogWrite(LEDstrip,0);
  }

  SensorReading = digitalRead(LaserSensor);
  if (SensorReading == HIGH)
  {

    digitalWrite(LED, HIGH);
  digitalWrite(alarmSpeaker, HIGH);
  if ((!timer0Fired) && (timer0 > interval)) {
    timer0Fired = true;
  digitalWrite(alarmSpeaker, LOW);
    }


  else
  {
    digitalWrite(LED, LOW);
  }
}
}
```

RESULT

The Laser tripwire system works perfectly, when an object blocks the laser ray falling on the LDR, the alarm system makes noise until the reset button is pressed.

The sound reactive LED strip also works perfectly in home environment.

PROSPECTS

The laser security system provides enhanced security to regular portals in commercial and non commercial use. This system is actively put to used by using reflectors to increase the area of cover until it reaches the LDR. This system can serve a role in the modernization of housing and security, this can either be used a peripheral layer to security or as a primary one where sensitive information and projects are to be secured.

The sound reactive LED system is focused to provide a dramatic ambience to entertainment where it can be used to produce analogue fluctuations in voltage to the strip making a great lighting effect which offers realtime interaction between sound and electricity.

BIBLIOGRAPHY

1. Wikipedia
2. Book, “Programming Arduino” by Simon Monk.

MOSPEC

PLASTIC MEDIUM-POWER COPLEMENTARY SILICON TRANSISTORS

...designed for general-purpose amplifier and low speed switching applications

FEATURES:

- Collector-Emitter Sustaining Voltage-
  $V_{CEO(SUS)}$ = 60 V (Min) - TIP120,TIP125
  = 80 V (Min) - TIP121,TIP126
  = 100 V (Min) - TIP122,TIP127
- Collector-Emitter Saturation Voltage
  $V_{CE(sat)}$ = 2.0 V (Max.) @ I_C = 3.0 A
- Monolithic Construction with Built-in Base-Emitter Shunt Resistor

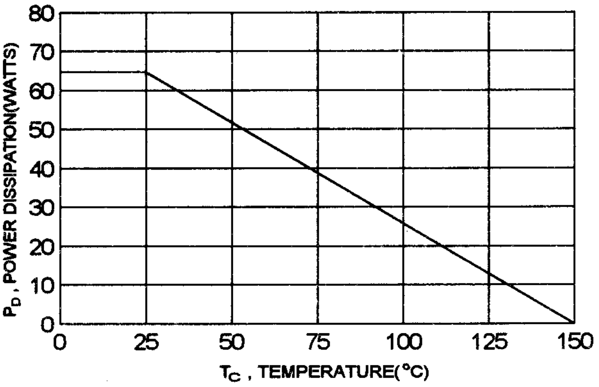
MAXIMUM RATINGS

Characteristic	Symbol	TIP120 TIP125	TIP121 TIP126	TIP122 TIP127	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	V
COllector-Base Voltage	V_{CBO}	60	80	100	V
Emitter-Base Voltage	V_{EBO}	5.0			V
Collector Current-Continuous -Peak	I_C I_{CM}	5.0 8.0			A
Base Current	I_B	120			mA
Total Power Dissipation @T_C= 25°C Derate above 25°C	P_D	65 0.52			W W/°C
Operating and Storage Junction Temperature Range	T_J ,T_{STG}	- 65 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Case	$R_{\theta jc}$	1.92	°C/W

FIGURE -1 POWER DERATING



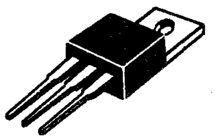
NPN **PNP**

TIP120 **TIP125**

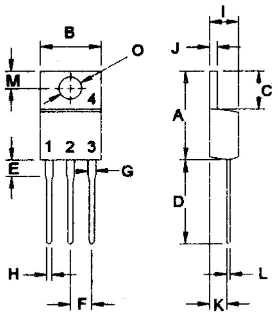
TIP121 **TIP126**

TIP122 **TIP127**

5.0 AMPERE
DARLINGTON
COMPLEMENTARY SILICON
POWER TRANSISTORS
60-100 VOLTS
65 WATTS



TO-220



PIN 1.BASE
2.COLLECTOR
3.EMITTER
4.COLLECTOR(CASE)

DIM	MILLIMETERS	
	MIN	MAX
A	14.68	15.31
B	9.78	10.42
C	5.01	6.52
D	13.06	14.62
E	3.57	4.07
F	2.42	3.66
G	1.12	1.36
H	0.72	0.96
I	4.22	4.98
J	1.14	1.38
K	2.20	2.97
L	0.33	0.55
M	2.48	2.98
O	3.70	3.90

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector - Emitter Sustaining Voltage (1)	$V_{CEO(sus)}$			V
(I_C = 30 mA, I_B = 0) TIP120,TIP125		60		
TIP121,TIP126		80		
TIP122,TIP127		100		
Collector Cutoff Current	I_{CEO}			mA
(V_{CE} = 30 V, I_B = 0) TIP120,TIP125			0.5	
(V_{CE} = 40 V, I_B = 0) TIP121,TIP126			0.5	
(V_{CE} = 50 V, I_B = 0) TIP122,TIP127			0.5	
Collector Cutoff Current	I_{CBO}			mA
(V_{CB} = 60 V, I_E = 0) TIP120,TIP125			0.2	
(V_{CB} = 80 V, I_E = 0) TIP121,TIP126			0.2	
(V_{CB} = 100 V, I_E = 0) TIP122,TIP127			0.2	
Emitter Cutoff Current (V_{EB} = 5.0 V, I_C = 0)	I_{EBO}		2.0	mA
ON CHARACTERISTICS (1)				
DC Current Gain	hFE			
(I_C = 0.5 A, V_{CE} = 3.0 V)		1000		
(I_C = 3.0 A, V_{CE} = 3.0 V)		1000		
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			V
(I_C = 3.0 A, I_B = 12 mA)			2.0	
(I_C = 5.0 A, I_B = 20 mA)			4.0	
Base-Emitter On Voltage (I_C = 3.0 A, V_{CE} = 3.0 V)	$V_{BE(on)}$		2.5	V
DYNAMIC CHARACTERISTICS				
Small-Signal Current Gain (I_C = 3.0 A, V_{CE} = 4.0 V, f = 1.0 MHz)	h_{fe}	4.0		
Output Capacitance	C_{ob}			pF
(V_{CB} = 10 V, I_E = 0 , f = 0.1 MHz) TIP120,TIP121,TIP122			300	
TIP125,TIP126,TIP127			250	

(1) Pulse Test: Pulse width = 300 us , Duty Cycle ≦ 2.0%

INTERNAL SCHEMATIC DIAGRAM

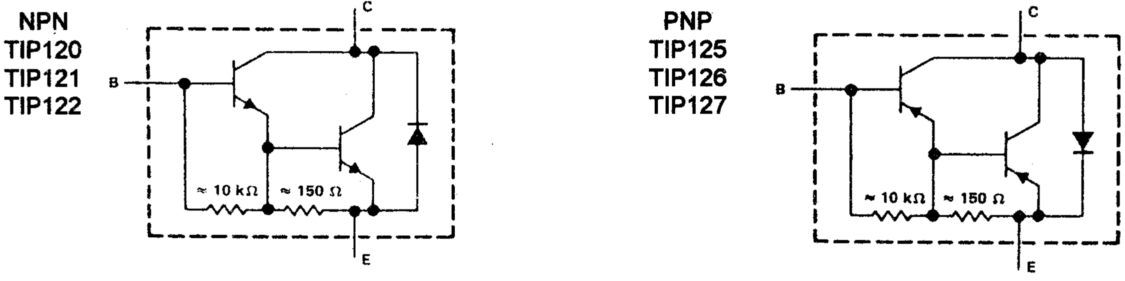


FIG-2 SWITCHING TIME

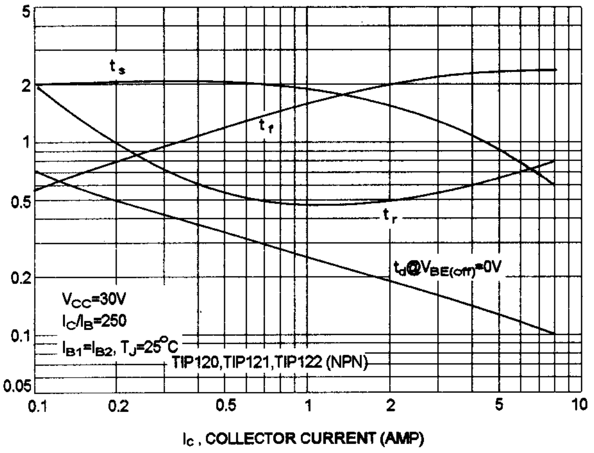


FIG-3 SWITCHING TIME

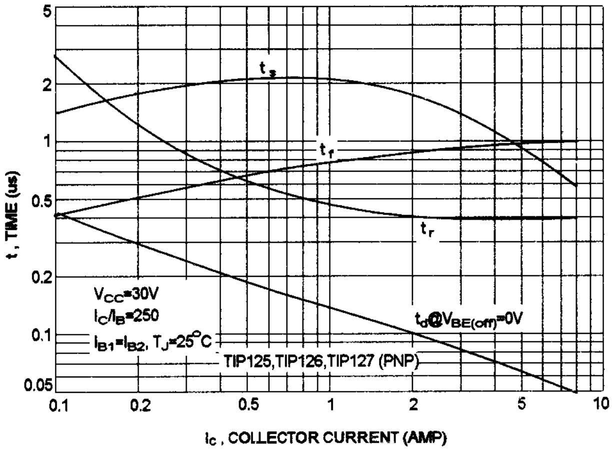


FIG-4 SMALL-SIGNAL CURRENT GAIN

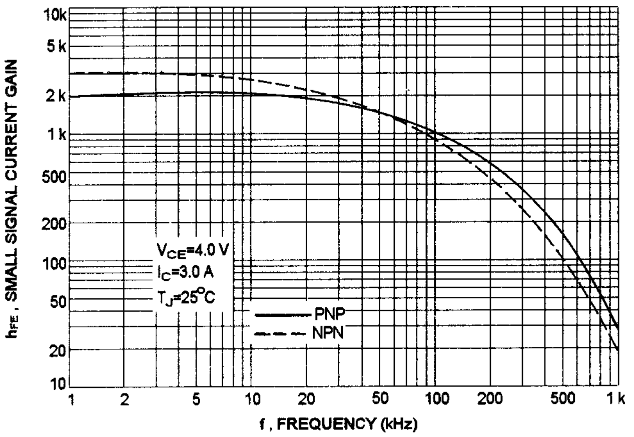


FIG-5 CAPACITANCES

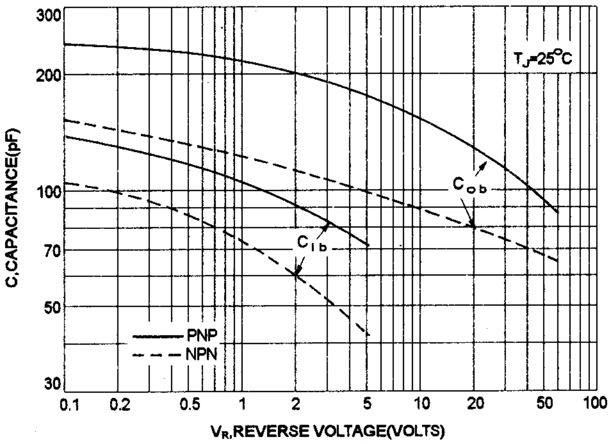
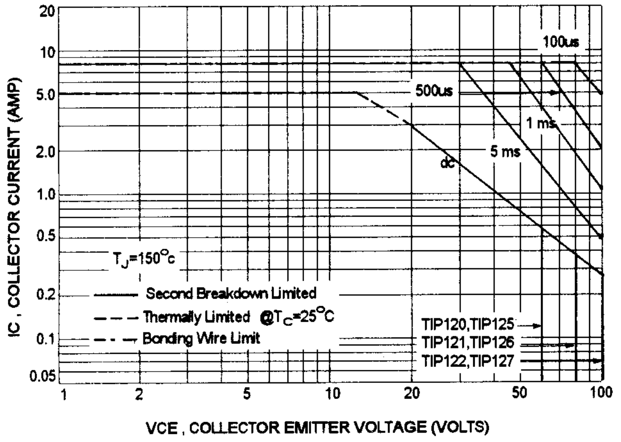


FIG-6 ACTIVE REGION SAFE OPERATING AREA



There are two limitation on the power handling ability of a transistor:average junction temperature and second breakdown safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than curves indicate.

The data of FIG-6 is base on $T_{J(PK)}$=150 °C;T_C is variable depending on power level.second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(PK)} \leq 150$°C ,At high case temperatures,thermal limitation will reduce the power that can be handled to values less than the limi - tations imposed by second breakdown.

NPN TIP120,TIP121,TIP122 **PNP TIP125,TIP126,TIP127**

FIG-7 DC CURRENT GAIN

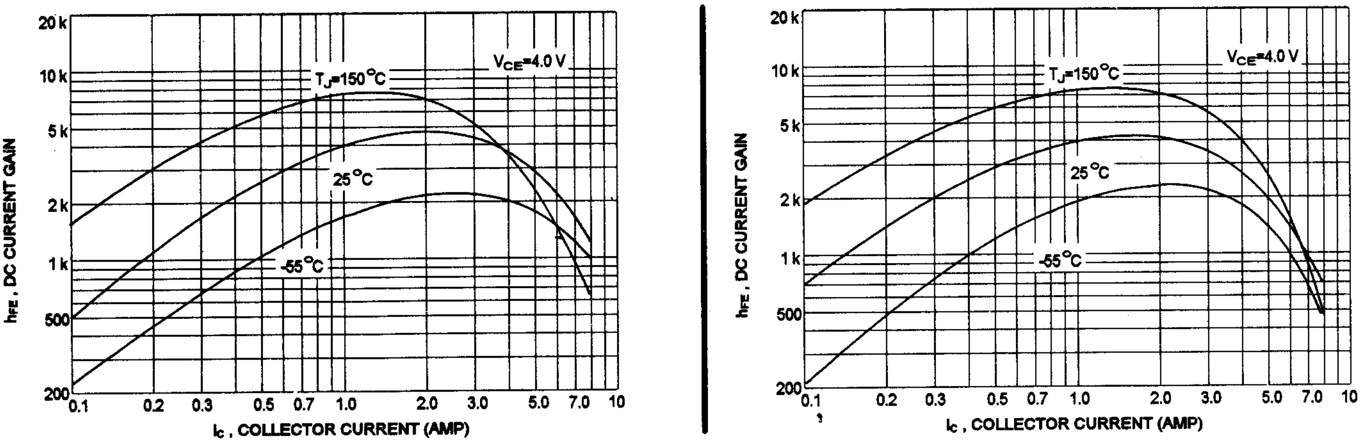


FIG-8 COLLECTOR SATURATION REGION

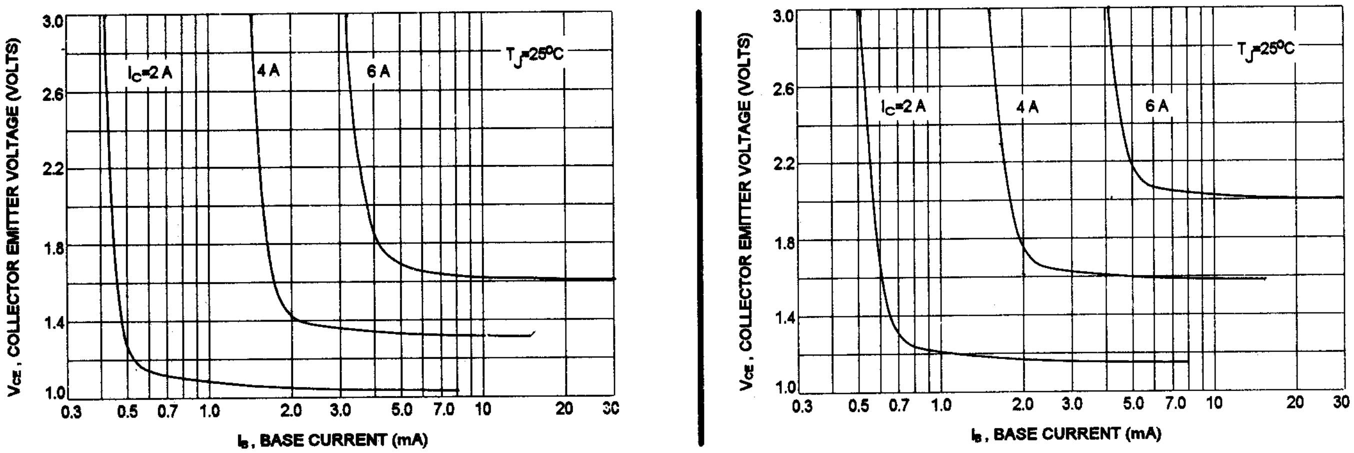


FIG-9 "ON" VOLTAGES